Shared Spectrum Access for Radar and Communications (SSPARC) DARPA BAA-13-24

Dr. John M. Chapin, Program Manager
Strategic Technology Office

Proposer's Day Presentation

February 26, 2013

Program Overview

BAA Logistics and Schedule

BAA 13-24 – Shared Spectrum Access for Radar and Communications (SSPARC)

Announcements

BAA was posted to www.fbo.gov on February 21, 2013

Schedule

BAA Released – February 21, 2013

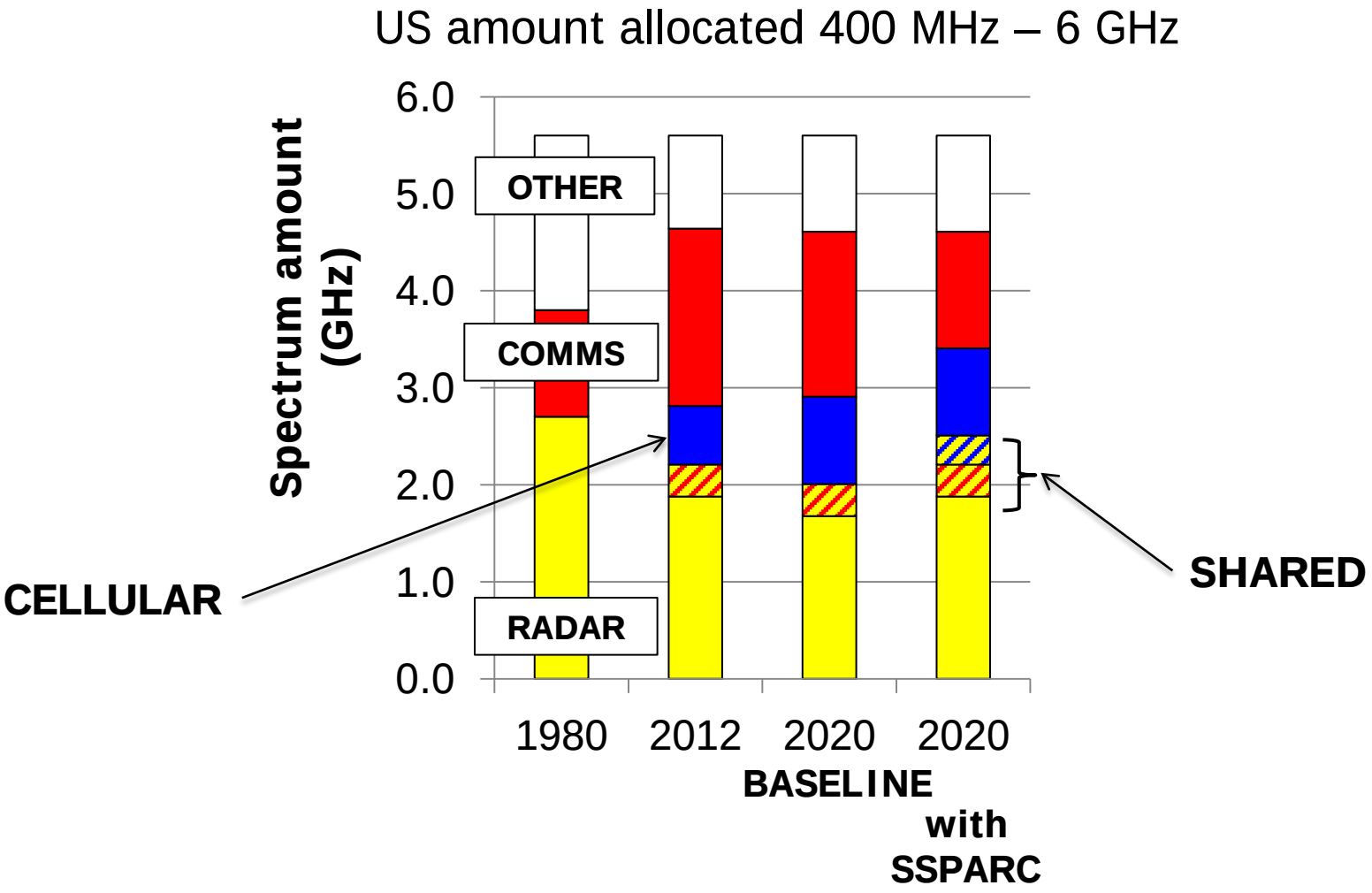
Proposal Due Date – April 9, 2013

Administrative, technical, or contractual questions should be sent via email to

DARPA-BAA-13-24@darpa.mil

BAA-13-24 and associated amendments, will be the official documents for this solicitation. They supersede statements made here.

Motivation for radar/communications spectrum sharing



Improve BOTH radar and communications capabilities

Summary of SSPARC challenges and approach

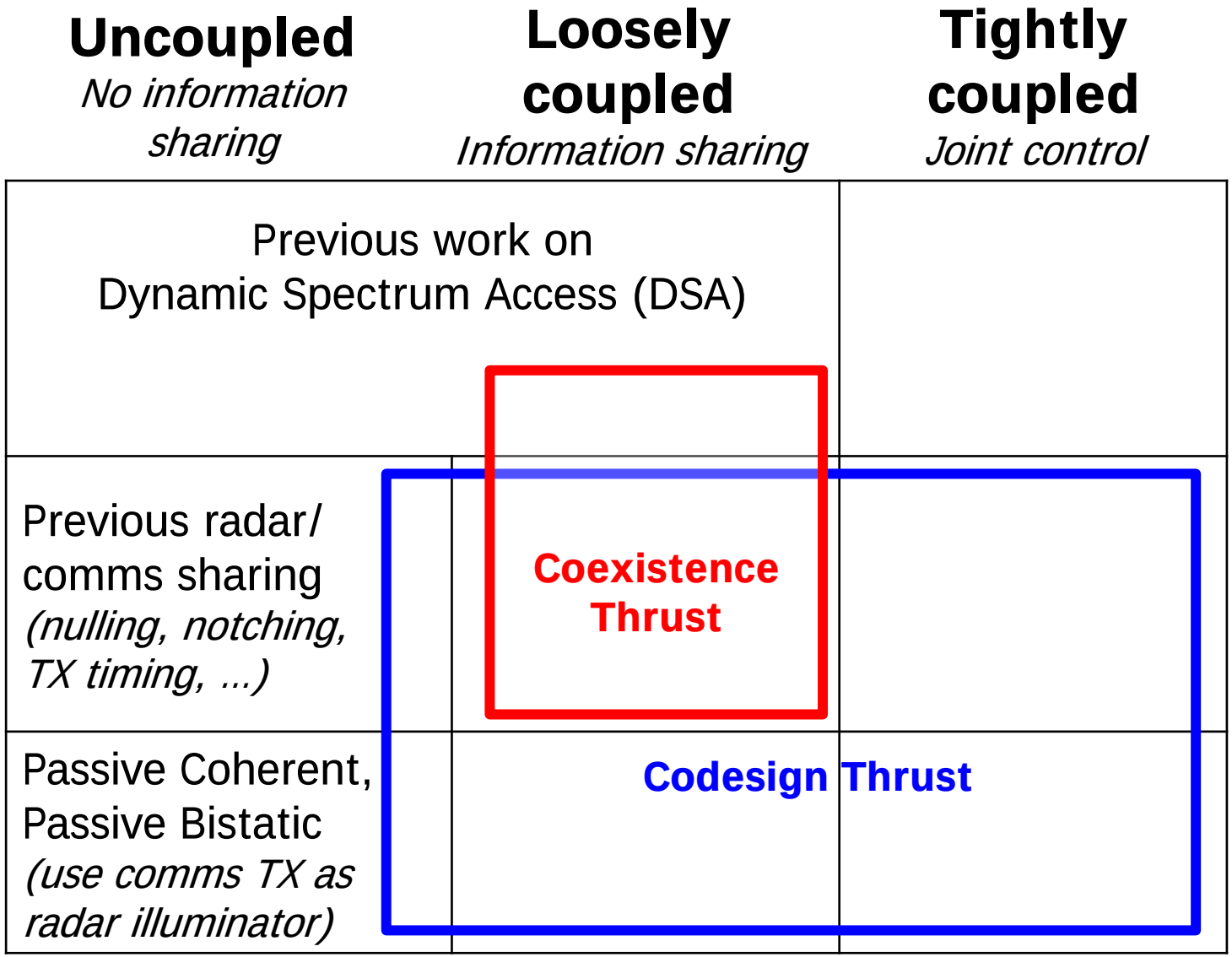
Challenges

- Combine (1) high performance of systems sharing the spectrum
  (2) low interference
  (3) low cost
- Radar OPSEC is critical
- Non-cooperative emitters may share the band
- Communications devices may malfunction

Approach

- Cooperation – exchange control information
  - Systems avoid each other based on actual usage, not potential usage
  - Integrate and balance a suite of mechanisms
- **Coexistence thrust:** upgrade to current radars
- **Codesign thrust:** fundamental system redesign

SSPARC program compared to related research



SSPARC research focus

Spectrum band

- S-Band 2 GHz – 4 GHz
- Band where radar and communications are most in contention

Radar

- Ground or naval-surface
- Electronically steered array
- Multifunction
  - Air surveillance, tracking, noncooperative target ID, weather

Communications

- Military MANET **military / military sharing**
- Commercial small-cell broadband (licensed/unlicensed) **military / commercial sharing**

Relationship between thrusts and sharing types

Thrust	Time frame	Military / Military sharing	Military / Commercial sharing
Coexist-ence	Rapid transition	✔	✔
Codesign	Slower transition	✔	
Comms nodes in radar range		2 – 1,000 nodes 0 – 60 km/hr	2 – 100,000 nodes 0 – 3 km/hr
Benefits sought		Improve both capabilities when in congested/contested areas	Preserve radar capability Meet needs for increased commercial spectrum Avoid radar relocation cost

SSPARC phases

Phase 1 – 12 months

- System concepts creation, analysis and simulation
- Supporting technologies
- Theory and fundamental limits

Performers define sharing situation

This BAA does not solicit proposals for Phase 2 or 3 work. Information presented below is subject to change.

Phase 2 – 18 months

- System design and development
  - including laboratory prototypes of key components
- Supporting technologies
- Theory and fundamental limits

Government defines sharing situation

Phase 3 – 18 months

- System integration and experimentation

Coexistence thrust goals by end of Phase 3

A. Experimental campaigns on spectrum sharing:
   - S-Band multi-function radar + Military MANET
   - S-Band multi-function radar + Representative small cells

establishing that harmful interference will not occur.

B. Establish effectiveness and feasibility for commercial use

C. Develop regulatory recommendations

Codesign thrust goals by end of Phase 2

- Establish confidence in the opportunity to:
  - Improve beyond state of the art in both radar and communications systems while incorporating spectrum sharing as a fundamental requirement
    - Codesign from the ground up
    - Cooperation and/or Joint Control
    - Combination of system-level and device-level separation
    - Combination of multiple device-level separation mechanisms
  - Exploit synergies between radar and communications devices, e.g.:

Supplemental illumination	Cooperative version of Passive Bistatic
Supplemental receivers	Nodes assist detecting low observable targets
Rendezvous support	Radar detects disadvantaged comms nodes

- Justify and scope a Phase 3 effort to build and demonstrate the systems

External inputs to assist progress and evaluation

DARPA anticipates:

- Establishing a red team of EW specialists and stakeholders from across the DOD to periodically assess implications for radar system protection
- Carrying out periodic reviews with regulatory stakeholders
- Performing a series of field measurement and characterization experiments of existing systems

Transition opportunities

Near-term 5 years

- Upgrade control system of existing radar and military communications network

Mid-term 5-8 years

- New rules for commercial entrants to radar bands
- Tech insertion into new military radios

Long-term 8+ years:

- Tech insertion into new radars

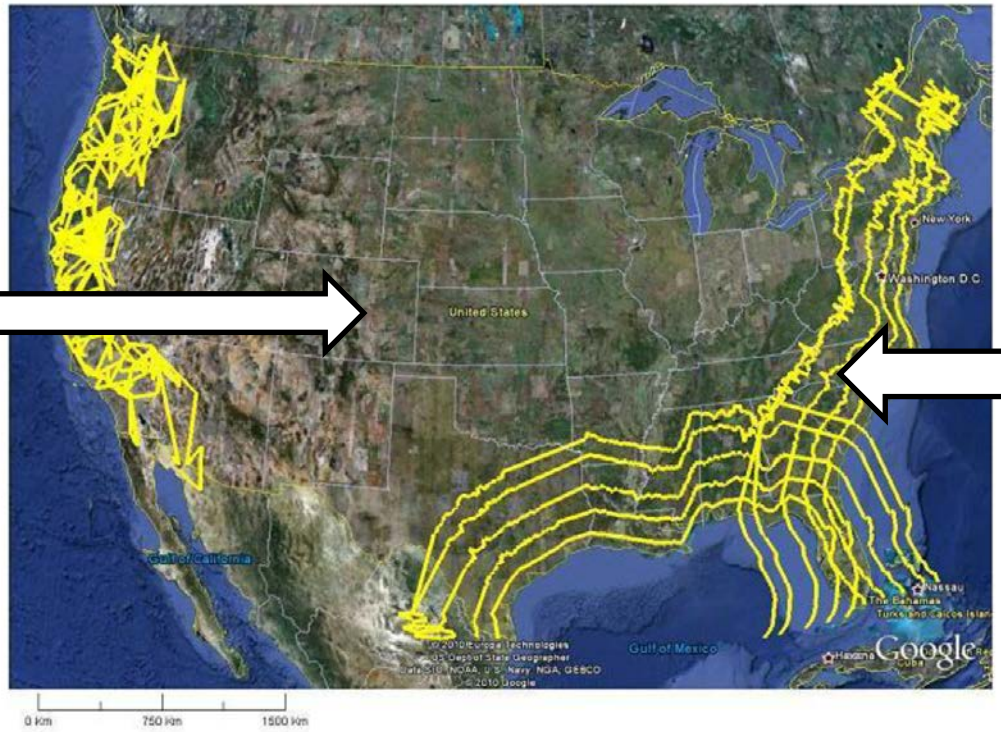
Separation Mechanisms

These are examples.
Additional separation mechanisms are sought for investigation.

Limitations of geographic isolation

NTIA study of WiMax sharing with 3550-3650 MHz Navy S-band radars.

WiMax networks may be deployed inland.



WiMax may not be deployed close to shore.
100-500 km standoff

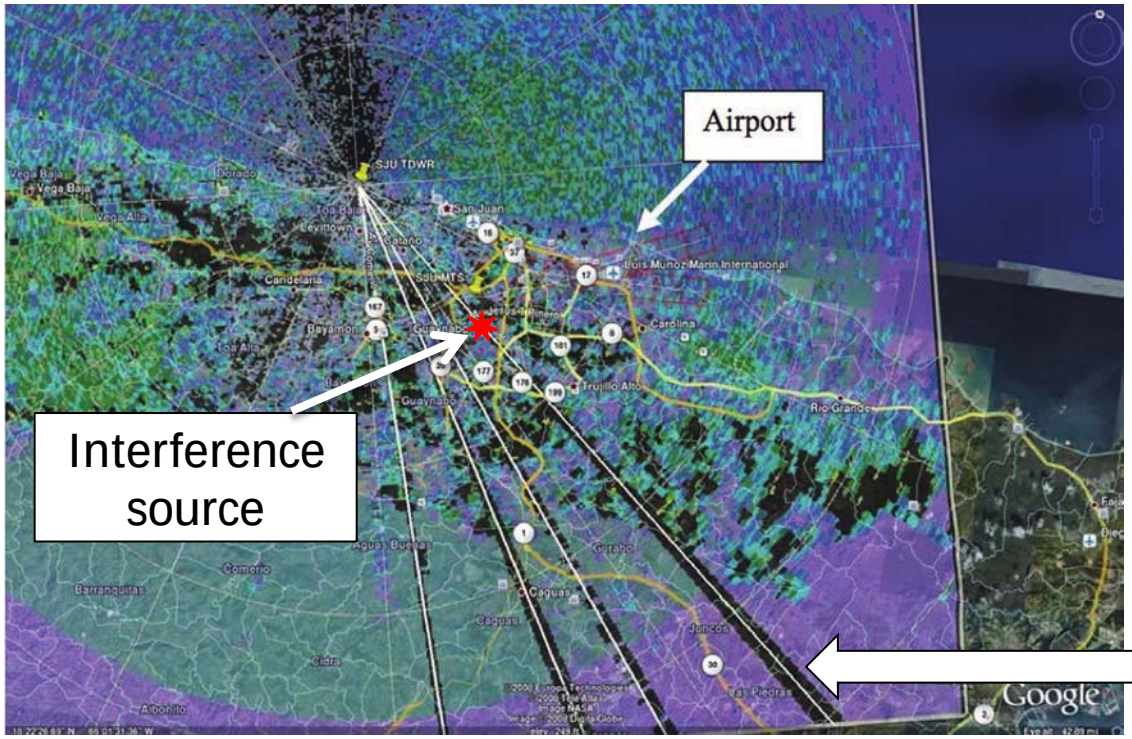
55% of US population lives within 80 km of shore.

NOAA analysis of US census data.

NTIA 2010, "An Assessment of the Near-Term Viability of Accommodating Wireless Broadband Systems in the 1675-1710 MHz, 1755-1780 MHz, 3500-3650 MHz, and 4200-4220 MHz, 4380-4400 MHz Bands"

Limitations of non-cooperative sharing

Example: 5 GHz doppler weather radar & WiFi LAN access point



Incident details:

- LAN access point < 250 mW
- In line of sight, 14 km from radar
- TX frequency 10MHz below radar band
- Transmitter leakage generated 6 dB interference/noise at the radar

Interference strobes

Field data from an incident in 2009, San Juan, Puerto Rico. Investigation results and figure from NTIA Technical Report TR-11-473

Spectrum access will be limited unless there is a mechanism to mitigate misconfiguration errors.

System-level separation mechanisms and challenges

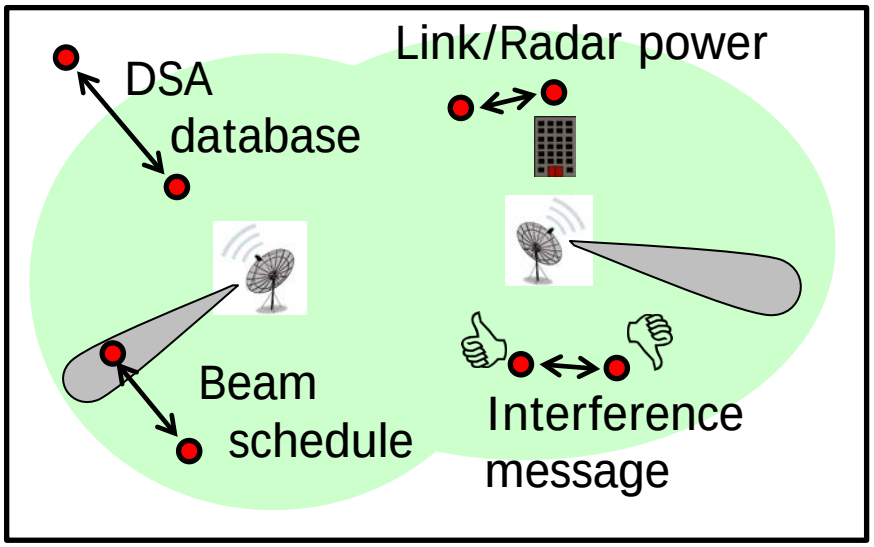
Establish a near real time information sharing system (direct link or relayed) between radar and radio nodes.

Geographic isolation

- Radar location OPSEC

Beam avoidance

- Radar behavior OPSEC
- Beam schedule length
- Data link design trades



Path loss estimation

- Radar transmit power varies
- Beam pattern OPSEC
- Coherence time, bandwidth

Reactive interference mitigation

- Rapid identification of interfering node
- Modify its settings to mitigate
- Fallback mechanism if mitigation fails

Device-level separation mechanisms

Hardware components, subsystems, waveforms, and signal processing methods that improve separation.

Category	Technique
Spatial	Antenna nulling
Spectral	RX frequency nulling TX frequency notches Dynamic range and filter improvements
Time	Pulse repetition correlation Interpolation across missing pulses Joint channel access scheduling
Waveform	Shaping, coding, polarization

Phase 1 Tasks

Phase 1 Tasks overview

- Task 1 – coexistence system concepts – 12 months
- Task 2 – codesign system concepts – 12 months
  - Creation, analysis, and modeling/simulation of system concepts
  - Both tasks consider system-level and device-level mechanisms
  - Include investigation of architecture and protocol for information sharing subsystem between radar and communications system
  - Investigate and identify specific current and future radar and communications systems for visualization of potential operational system implementations
- Task 3 – supporting technologies – 12 months
  - Focused efforts on individual technologies
  - Emphasis: innovative separation mechanisms for codesign thrust
- Task 4 – theory and fundamental limits – 30 months
  - Information theoretic limits, grounded design techniques, ...

Task 1 – Coexistence system concepts

- Mechanisms proposed should support rapid transition to operational use
- Support both military/military and military/commercial sharing
- Future systems from any vendor should be able to participate

- Military/military sharing
  - "Harmful interference to primary is defined as application-level or mission-level performance impairment"
- Military/commercial sharing
  - Commercial systems continue operating when near a radar at an elevated threat level
  - Research on issues related to standardization and regulatory action is within scope
  - Cost minimization and privacy protection for commercial systems/users

Task 1 special evaluation criteria (BAA section 5)

The proposed team has expertise in

- radar system design and operation,
- military communication system design and operation,
- EW threats to and countermeasures for radar and communications systems,
- commercial communications systems design, operation and standards, and
- US and international spectrum regulations and regulatory processes.
    - *Critical disconnects exist between these communities that could slow progress or lead to suboptimal research outcomes.*

The proposed work effort is structured in a way that integrates experts in all these areas into a tight team.

- *Examples of approaches to address this challenge include colocation of key program participants in a single building and intensive cross-training.*

Task 1 special evaluation criteria (BAA section 5)

The evaluation will take into consideration

- the extent to which the proposed technical deliverables support the goal of rapid transition,
- the extent to which the proposed intellectual property (IP) rights support the goal of easy participation in the spectrum sharing system by any vendor, and
- the extent to which the technical deliverables and IP rights support eventual standardization, regulatory action, and commercial adoption of military/commercial sharing technologies.

Task 2 – Codesign system concepts

- Mechanisms proposed should enable improved spectrum sharing through exploiting the opportunity to codesign the systems
- Exploit new synergies to improve performance beyond state of the art
- Support military/military sharing
- Single allocation spectrum sharing

- Task 2 special evaluation criteria (BAA section 5)
  - The proposed team has expertise in radar system design and operation, military communications systems design and operation, and EW threats to and countermeasures for radar and communications systems.
  - The proposed work effort is structured in a way that integrates experts in all these areas into a tight team.
    - *Same comments regarding disconnects and approaches as for T1.*

Task 3 – Supporting technologies

- May apply to either or both thrusts
- May apply to any part of the sharing problem

- Proposal must estimate quantitative costs/benefits
- Interim technical report due 8 months into effort

- Task 3 special evaluation criteria (BAA section 5)
  - The evaluation will consider whether the technology will reach a sufficient level of maturity in time to be incorporated into a system prototype in Phase 2 or Phase 3 of the SSPARC program.

Task 4 – Theory and fundamental limits

Interest includes information, control and coding theory

Example questions

- Information theoretic limits on radar performance given a channel partially occupied by a codesigned communications waveform
- Limits of successive interference cancellation techniques
- Communications capacity when sharing with radar

Total 30 months

- Base period up to 14 months, technical report 2 months before end
- Subsequent option period

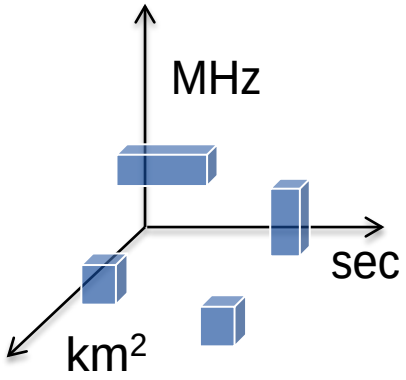
Define a challenge problem 4 months into project that will be used to relate research results to program goals.

Metrics

These metrics are for Task 1 and Task 2.
Task 3 and Task 4 proposals should suggest the metrics that will be used to evaluate the research.

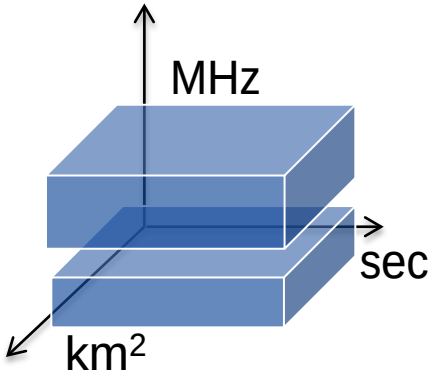
Abstract Metric: Spectrum Access (SA)

Operation of system X in a band/area defines zones that limit operation of system Y:



Interference zone

Operation of system Y would cause harmful interference to X



Exclusion zone

System Y may not operate.
Superset of interference zone

Operation ≡ system transmits as needed to accomplish its mission (e.g. power level, direction, duty cycle, codes).

Harmful interference ≡ a performance reduction determined by the commander

Coexistence thrust:
reduce exclusion zone

Codesign thrust:
reduce interference and exclusion zones

Spectrum Access

$SA_X(Y)$ = % of volume not excluded

Proxy metric: minimum separation distance between radar and communications network

Metric	Coexistence (Task 1)	Codesign (Task 2)
Line-of-sight standoff	5x standoff reduction	10x standoff reduction
Propagation exploitation	Additional 4x standoff reduction	
Target when combined	5% of baseline standoff	2.5% of baseline standoff

Baseline standoff for computing reductions: distance required between cochannel radar and communications system so that each achieves at least 95% of its standalone performance.

Proposers are encouraged to provide additional performance parameters that effectively characterize the spectrum access benefits of their solutions.

Additional metrics

Interference events	Radar experiences interference events < 1 per 120 sec Mitigate 95% of interference events in 2 sec, 99.9% of events in 60 sec.[4] In 95% of events, mitigation only impacts node causing interference.
Synergistic behaviors (codesign thrust only)	Radar $P_D \geq 0.75$ in conditions where radar standalone has $P_D \leq 0.5$

Note 4. Even in cases where a node does not receive or properly process messages telling it to modify its behavior

Award Information

Award Information

- Multiple awards are possible
- Funds awarded will depend on quality of the proposals received and availability of funds
- If warranted, portions of resulting awards may be segregated into pre-priced options
- An organization or team may perform on multiple tasks
  - Each task offered must be in a separate proposal.
  - Multiple supporting technologies may be investigated in a single Task 3 proposal if the work forms a coherent program.
  - If Tasks 1 and 2 are both proposed, cost savings are expected if both are awarded and should be described in both proposals.

Prepublication review and classification

- Tasks 1, 2 and 3 are not expected to be “fundamental research”
  - DARPA anticipates requesting proposers and their subcontractors to agree to prepublication review
  - A security classification guide is available upon request

- Task 4 may be “fundamental research”
  - DARPA does not anticipate applying prepublication review
  - A security classification guide is not offered at this time

- Notwithstanding the above, the Government recognizes that proposed research solutions to any task could be of either a fundamental or restricted nature.

Mandatory financial summary slide (BAA Appendix 1)

Element	Base	(options, 1 column each, if any)	(Total, if there are options)	(Task 1 & 2 together, if applicable)	Comments
Contract Type					Enter CPFF, CPAF, FFP, etc.
Number of Months					
Prime Labor					Dollars (loaded with labor overhead but excluding G&A)
Prime Labor Hours					
PI Effort Level					Express as % of full time
PM Hours					Express as number of hours. Omit if same person is PM and PI
Prime Materials					Dollars (unloaded)
Prime Travel					Dollars (unloaded)
Subcontractor - <Name>					Dollars (unloaded). In this comments column, enter contract type e.g. CPFF, T&M.
(repeat for more subs, if any)					
General and Administrative					Include all costs not included above or as fee, e.g. loading on materials and subs.
Fee					Express as % of the sum of the above dollar amounts, not as dollars
Additional costs					Dollars. E.g. CAS 414
Total					Should equal the sum of the cost rows. Should match proposal.

Thank you for your interest in the SSPARC program